STAT

Preliminary Report - Laser Optometer Experiment

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The purpose of this experiment was to determine if the laser scintillation pattern, LSP, could be used to measure refractive state without disturbing the subject's accommodation to some visual target. If the LSP does not in itself serve as a stimulus to accommodation it is then reasonable to assume that the subject's focus is determined by other stimuli in his field of view.

The general method of using the laser to measure accommodation requires that the LSP be present in the subject's field of view and that a series of lenses be placed in the optical path between the subject's eye and the LSP in order to neutralize motion of the pattern. Thus, there were two specific questions to be answered: (1) Could a subject report the direction of the apparent movement of the LSP superimposed over part of his central visual field while still focussing on the primary target, and (2) Would the introduction of lenses cause a disturbance of accommodation? The opportunity to answer these questions arose during part of a study to determine the effects on accommodation brought about by changes in the convergence angle of the eye pieces of a binocular microscope. For this study accommodation was monitored continuously by a high-speed infrared optometer (Crane and Cornsweet, 1967, 1969). During part of the experiment measures of accommodation were made simultaneously by the infrared optometer and the laser technique.

Four adult males, 44, 30, 45, and 26 years of age served as subjects. No corrective lenses were worn during the experiment although one subject (#2) was strongly myopic and the other three had minor refractive errors. See Appendix __.

The apparatus consisted of a low power binocular microscope of special construction with eye pieces maintained in a horizontal plane, the infrared optometer and the laser target. The subject sat in a chair with his head

position fixed by a biteboard such that his eyes were situated at the proper eye relief distance of fifty millimeters from the microscope. A dichroic mirror, part of the optometer, was positioned between the subject's left eye and a microscope. Because of constraints on the positioning of the optometer and microscope in relation to the subject's left eye, it was necessary to present the LSP in the visual field of the right eye. A beam splitter of approximately 30% transmission was mounted between the subject's right eye and the microscope at a 45° horizontal angle. A mirror reflected the image of the LSP on to the beam splitter. The subject thus saw a circular pattern of red light superimposed over about one-third of the field of the microscope which subtended a visual angle of ___ degrees. A shutter placed between the laser source and the target drum was used to control the duration of the subject's view of the LSP. The target drum, 4 in in diameter and 3 in wide, was located at an optical distance of 2 meters.

The output of the optometer calibrated in diopters was recorded by a Brush polygraph. An adjacent tract on the polygraph recorded the output of a photo sensitive cell placed near the laser target to monitor the onset of the LSP. During the phase of the experiment which involved placing lenses between the beam splitter and laser target, the time of placement and removal were marked on the polygraph record by an assistant. The experimental room contained a great deal of apparatus. During the course of the experiment the room lights were off, but stray light from the microscope stage lights and the polygraph chart light filled the room with dim illumination.

The procedure was a continuation of the convergence experiment which took place for about fifteen minutes preceding the laser test during which time the subjects were required to perform a visual search task. The field of the microscope consisted of a 10 by 13 matrix of circles which varied independently in size and contrast. One circle of each line was stereoscopically displaced

in depth. The subjects were required to identify the stereo circle and then trace equal constrast and equal size trails through the matrix. All the subjects were therefore acquainted with the microscope and optometer. Prior to the experiment all the subjects were shown the LSP and had a good understanding of the technique as well as being able to recognize the granularity and its apparent movement.

Instructions given at the time of the experiment consisted of a description of the protocol and directions to give a hand signal by pointing up or down depending on which way the LSP appeared to move. Subjects were also told to look at the portion of the field which was covered by the LSP. No specific information was initially given to maintain concentration on the microscope target. The first subject, however, volunteered the information that he was actively concentrating on the microscope target to avoid distractions by some portions of the room near the target drum that were illuminated by stray light. The second subject was not given instructions to concentrate on the microscope target and reported being disturbed by the extraneous reflections. The third and fourth subjects were then given explicit instructions to concentrate on the microscope target when the LSP was flashed.

The experiment was carried out in two phases; the first consisted of presenting the LSP for time periods of 1.0, 0.5, and 0.2 second. At some variable interval of about 1 to 5 seconds prior to flashing the LSP the experimenter would call out "ready" as a warning signal. The subject was asked to indicate by pointing the direction of the apparent movement, either up or down. For the first two subjects the direction of motion of the target drum was alternated randomly among up, down, and stationary to determine the accuracy of the directional response. Since all subjects exhibited myopia in this experiment it was possible to determine the correctness of the pointing response. For the second two subjects the drum direction was constant and the subject

indicated whether he could perceive the apparent direction of movement.

The second phase of the experiment consisted of introducing lenses between the right beam splitter and the laser target to determine if this procedure would disrupt the subject's accommodation. For this phase the LSP was left on continuously. Lenses from a standard optician's trial set, ranging from +1 to -6 diopters, were placed by the experimenter into a holder and left in place for approximately 20 seconds and then removed. As the experimenter placed and removed the lenses he called out "lens in", and "lens out", as a warning to the subject and to notify his assistant to mark the polygraph record.

Results and Discussion

Due to time considerations and trials invalidated by eye blinks, it was not possible to give all subjects the same number of trials in the two phases of the experiment. Data from the first phase of the experiment, the time LSP presentation, are show in Table 1.

	Duration of LSP					
	1 sec.		.5 sec.		.2 sec.	
Sub.	no change	change	no change	change	no change	chang
1	8	1	9	0	7	1
2	0	6	0	4	1	3
3	5	0	6	0	7	0
4	5	0	7	0	9	0
TOTAL	18	7	22	4	24	4

Table 1. Accommodative responses to introduction of the LSP.

On the oscillograph record, continuous, rapid oscillations of accommodation of about .3 diopter were evident for all subjects. For scoring purposes, a response was defined as any change in accommodation which followed the presentation of the stimulus within 3 seconds and either exceeded .5 diopter for more than 200 milliseconds or in the case of slow shifts, rose to a level greater

than .3 diopter for more than 1 second. This set the criteria so a response could clearly be differentiated from the continuous rapid oscillation. Typically, a response was a rapidly rising increase in accommodation greater than .5 diopter lasting for 3 or 4 seconds. It can be seen from the first table that definite changes in accommodation occurred for only one subject during the LSP presentations. This change may be due to the distractions present in the LSP field mentioned earlier. Another feature of this one subject's data was that accommodative changes occurred in some of the later trials after the "ready" warning but before the presentation of the LSP, suggesting that the subject was predisposed to shift his gaze or attention upon presentation of the LSP. The data of the other three subjects are quite uniform and consistant with one another. It seems reasonable to conclude that the presentation of the LSP in itself does not cause accommodative changes so long as the subject maintains his attention and fixation on the visual target in his direct field of view. From these data it is also evident that there are no accommodative differences related to the length of the LSP presentation for the durations used.

The data for the second phase of the experiment are shown in Table 2. The results for the lens test are similar to those of the time presentation; there were no apparent changes in accommodation due to the introduction or removal of lenses.

Sub.	lens in		lens out	
	no change	change	no change	change
1	4	0	4	0
2	4	1	5	0
3	5	0	5	0
4	29	0	29	0
TOTAL	42	1	43	0

Table 2. Accommodative responses to introduction and removal of lenses.

The subjects' reports of the direction of movement during this phase of the experiment seem to indicate a loss of ability to detect the motions for durations less than .5 second. See Table 3. There are, however, complications which limit these conclusions. First, the speed of the apparent motion is directly related to the degree of ammetropia. Thus, regardless of the speed of the drum, the apparent motion may be very slow or very fast. If the subject is accommodating very closely to the distance of the laser target he may not be able to detect motion in short presentations of the LSP as readily as he could were his accommodative error greater. On the other hand, assuming that the subject is accommodating very nearly to the proper distance, speeding up the drum will often increase the apparent speed of the LSP. For detection of small differences of accommodation with short durations of presentation of the LSP we increase sensitivity by increasing the speed of the drum. The directional report data given above then, are quite severely limited to the context in which they were taken. They do indicate, however, that there is some possibility of obtaining valid reports of apparent direction of movement at durations of less than .5 second. This may be a desirable feature since it would be necessary to obtain a measure of accommodation prior to the latency of response time of about 400 milliseconds, (Cornsweet, 1969; Starks, 1968: Campbell and Westheimer, 1959), if we had reason to believe that the LSP was serving as a stimulus to accommodation. This, of course, now seems unlikely in light of the data shown in Tables 1 and 2.

	Duration					
	1 sec.		.5 sec.		.2 sec.	
Subject	correct	incorrect	correct	incorrect	correct	incorrect
1	9	0	9	0	4	4
2	6	0	5	0	0	4
	15	0	14	0	4	8

Table 3. Subjects' reports of the direction of apparent motion of the LSP for 3 durations of presentation.

A third phase of the experiment consisted of comparing subjective reports of neutrality of movement of the LSP while measuring accommodation with the optometer for subject #4. Because of time considerations it was not possible to arrange to present visual targets at different doptric differences and therefore a secondary method had to be employed using only one subject.

This subject has some voluntary control and was able to change his accommodation until the LSP appeared either to be stationary or move in an indefinite direction. A series of lenses ranging from +1 diopter to -6 diopter were placed in the lens holder between the subject's eye and the LSP. The LSP was left on continuously and the subject would indicate when it was neutralized by pressing a button which actuated one of the pens on the oscillograph. Thus, comparisons could be made between the optometer record and the subjective indications. For the first thirty trials it was noted whether changes in accommodation were being promoted by the initial insertions and removal of the lenses. This explains the large number of trials for this one subject shown in Table 2. Inspection of the oscillograph record showed wide variations in accommodation during the period which the subject indicated that the LSP was neutralized. At the conclusion of the experiment the subject indicated that after initial neutralization the apparent movement would vary from up to down although he attempted to keep the movement neutralized. During that time he would keep the button pressed down until he relaxed his accommodation. A line representing the mean amplitude over the range during which the subject indicated neutralization was visually fitted to the data. The averages for these fitted lines are shown in Table 4.

Stimulus Lens (diopters)	Mean Response (optometer)	N
+1	no response	2
-1	1.0	9
-1.37	1.4	2
-1.5	1.7	2
-2.0	1.8	5
-3.0	2.6	4
-4.0	2.8	4
-6.0	5.5	2

Table 4. Mean diopter change of accommodation.

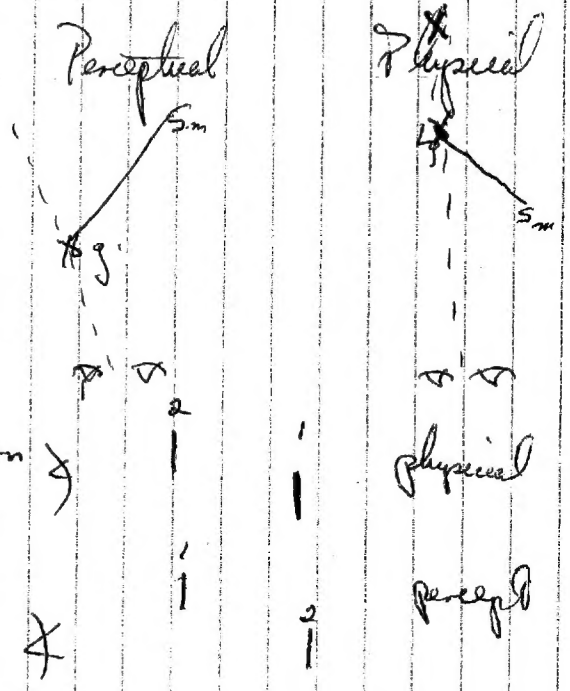
It appears for lenses of low dioptric strength that the laser and optometer methods agree quite closely. For lenses greater than -2, however, there seems to be a rather large disparity between the subject's indications and the readings of the optometer. Upon questioning the subject reported that for some of the larger strength lenses he did experience diplopia. The effort of accommodation was probably causing a convergence break of fusion. In this case it would be asymmetric convergence by the left eye since the subject was attending to the LSP which was directly in the line of sight of the right eye. It does not seem likely that these differences are due to artifacts of the recording by the optometer since ordinary shifts of gaze from left to right or up to down did not shown appreciable changes in the output on the oscillograph record. It is possible that the subject's two eyes were not responding identically for large differences in the stimulus to accommodation. Rosenberg, et.al., (1953) have shown that the accommodation of an asymmetrically converged eye is less by a predictable amount when the subject is fixating binocularly. In the present case, however, the subject fixated the LSP monocularly and the differences found would not be predicted by Rosenberg's data. A last alternative is that the

tensions on the converged eye from the extraocular muscles may have caused an increase in the intraocular pressure with a resulting lessening of the refractive power of the left eye due to the flattening of the cornea (Helmholtz, 18__). It will be possible to investigate these last two possibilities in the future by comparisons of the apparent movement of the LSP seen by the two eyes of the subject under the appropriate visual conditions similar to those described above. The subjects will view the LSP with a 3 or 4 diopter prism in front of one eye, base down, with a resulting diplopic image of the pattern which can then be individually neutralized to determine the refractive state of the two eyes.

From the above experiment we may conclude that it is possible to use the LSP to determine changes of refractive state without inducing changes in accommodation while taking the measurements. Since no apparatus other than a lens need be placed in the subject's visual field experimental artifacts such as instrument myopia are obviated. Lastly there appears to be no constraint on the duration that the LSP is present in the visual field of the subject, and either short or long durations may be used depending on the requirements of the experiment.

① '56

Trapezoidal window -- don't measure along same line of regard
Place retinal ON object (each) -- otherwise, mar perceptual,
not physical distance.



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